Realizing the next growth wave for semiconductors – A new approach to enable innovative startups
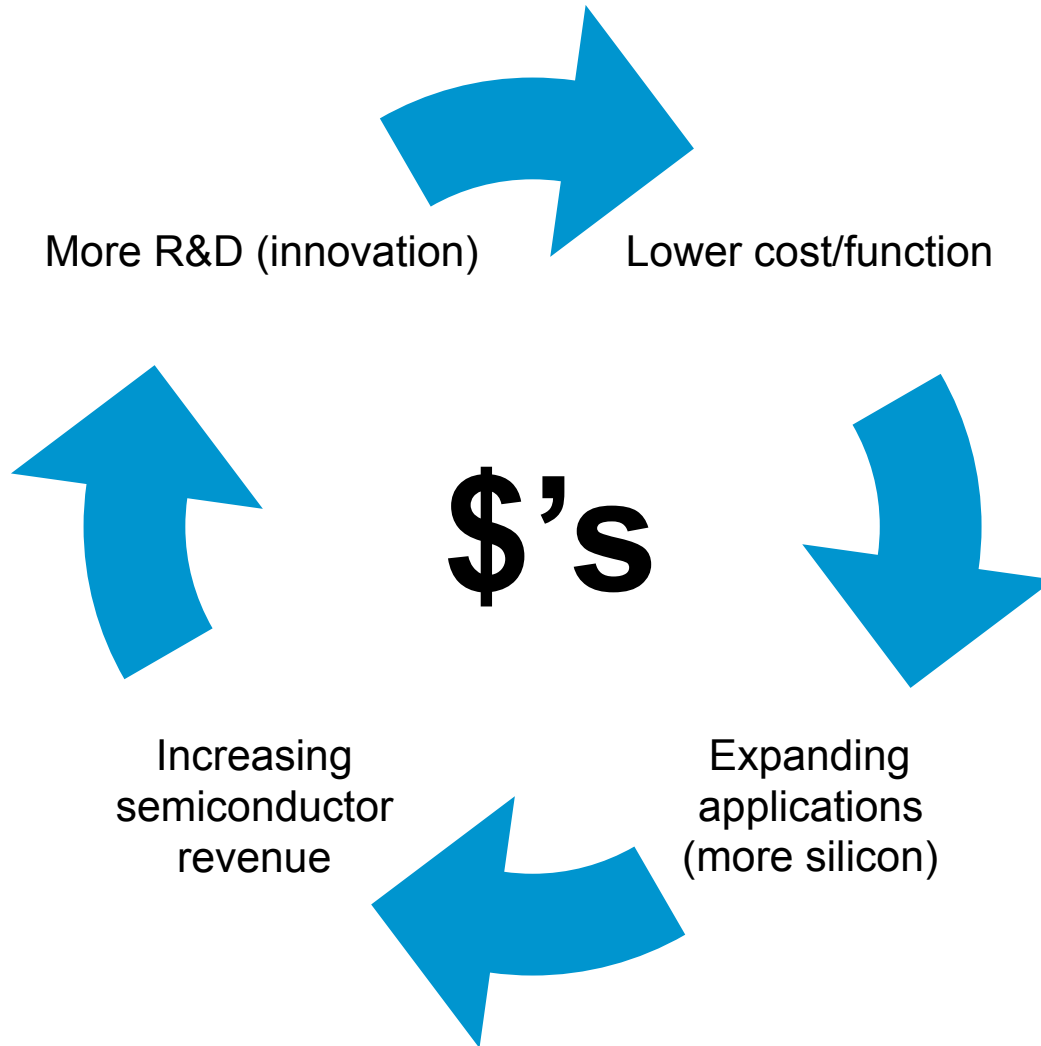
Daniel Armbrust

Stanford EE380

January 14, 2015
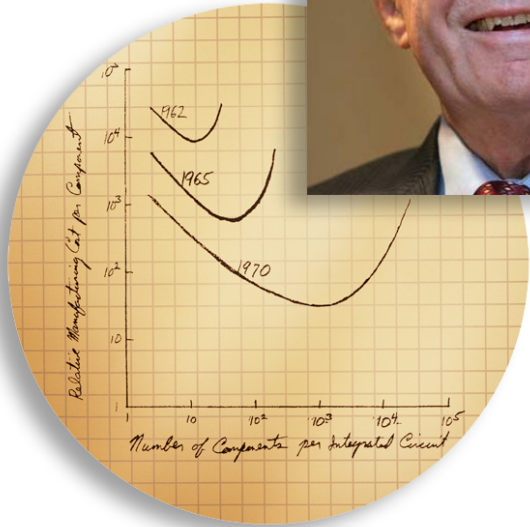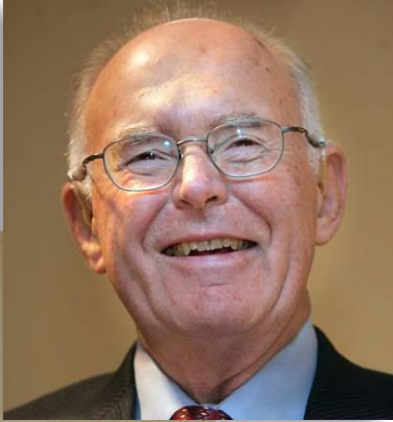
- Industry health – A perspective -

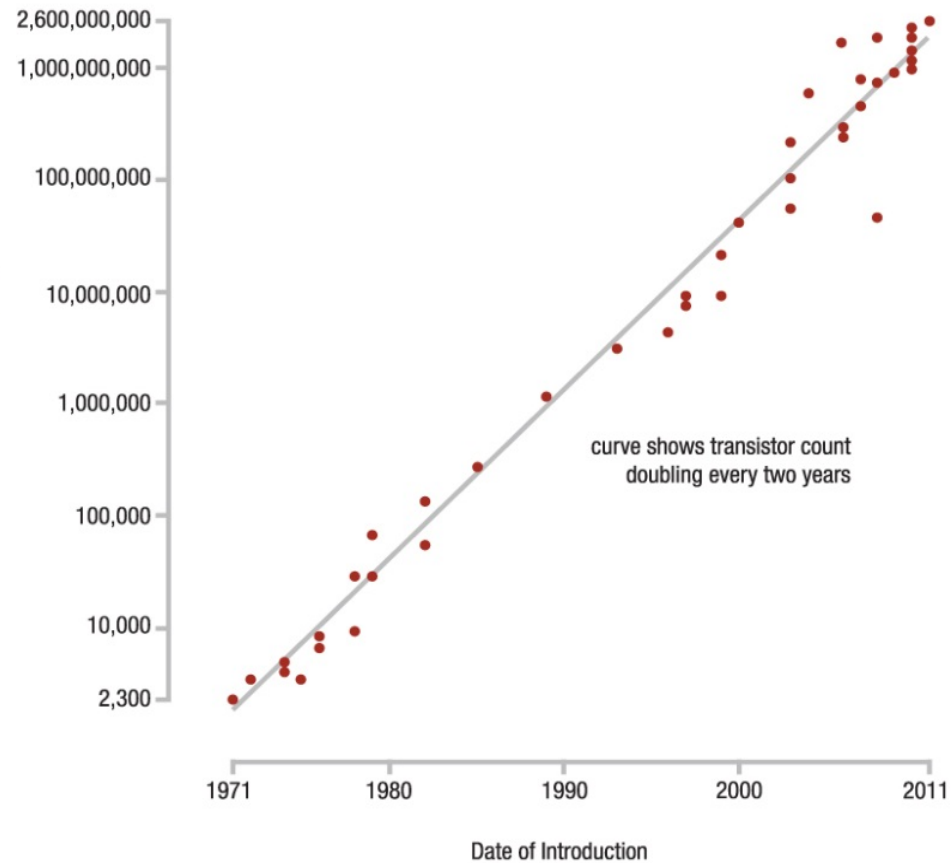# Semiconductor industry's virtuous cycle

Moore's Law continues
... remember it is an economic-based prediction

**Microprocessor Transistor Counts
1971-2011 & Moore's Law**

curve shows transistor count
doubling every two years

Date of Introduction

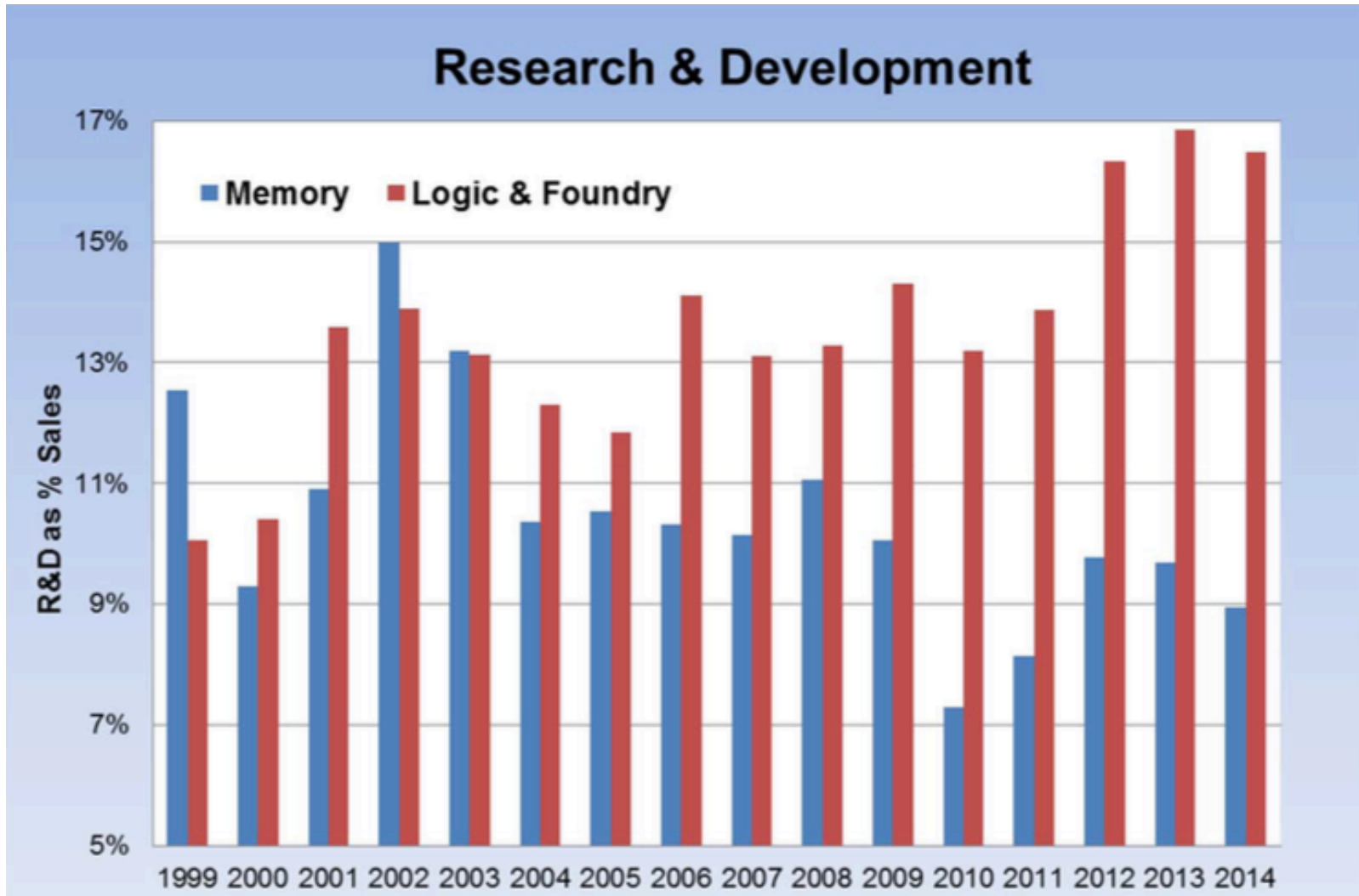# Semiconductors just reached record revenues …

Worldwide Semiconductor Revenue
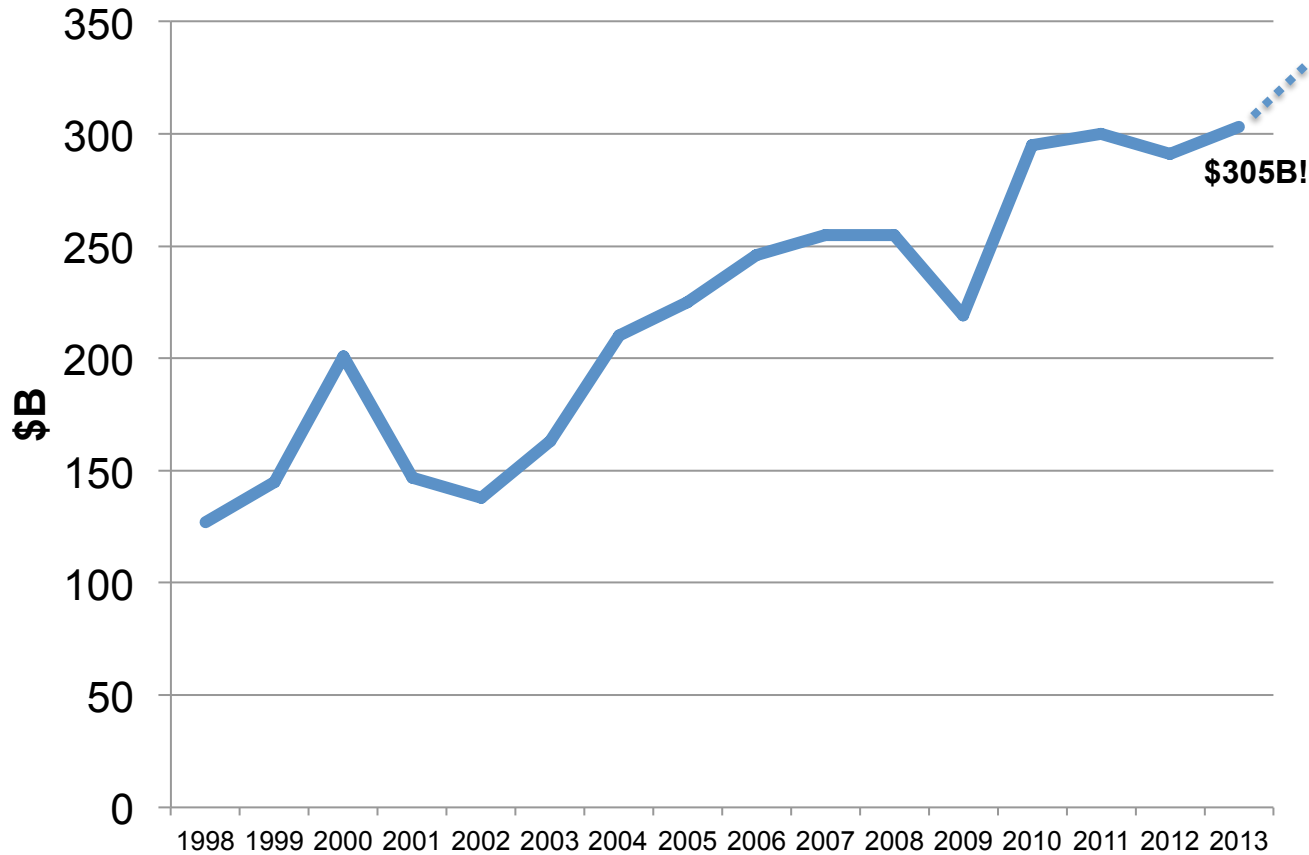
Source: WSTS 2/14

… so everything must be going well?

... and R&D spending continues to rise

Source: VLSI Research

... but underlying trends are not good

Growth is slowing

EBITDA is down

Development costs are skyrocketing
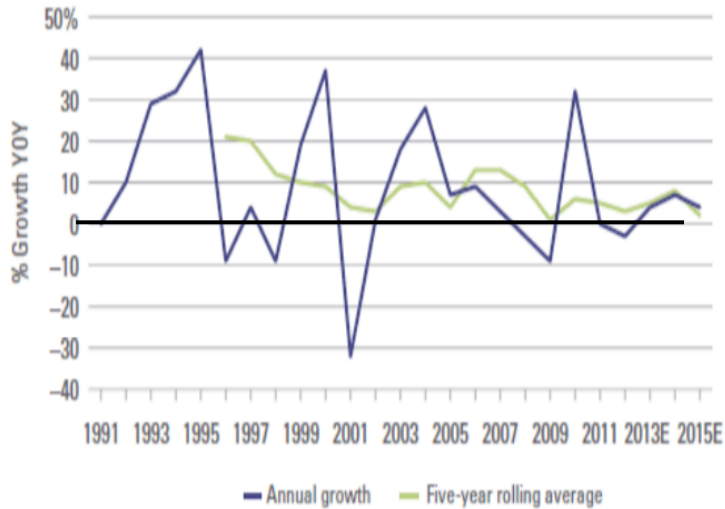
Source: SIA, AlixPartners
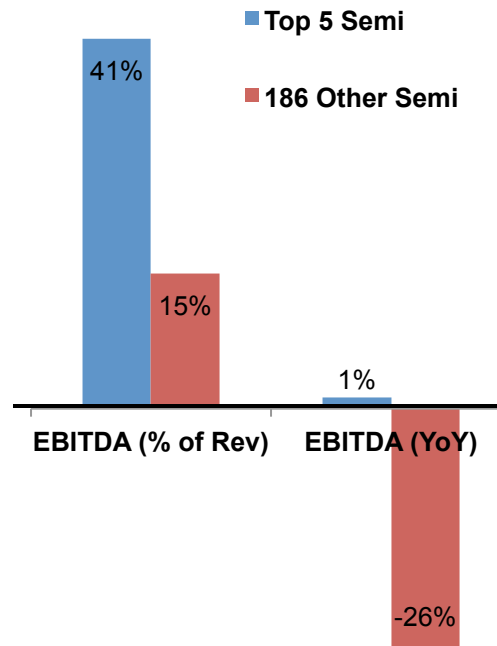
Source: 2012 Data, AlixPartners 2/14
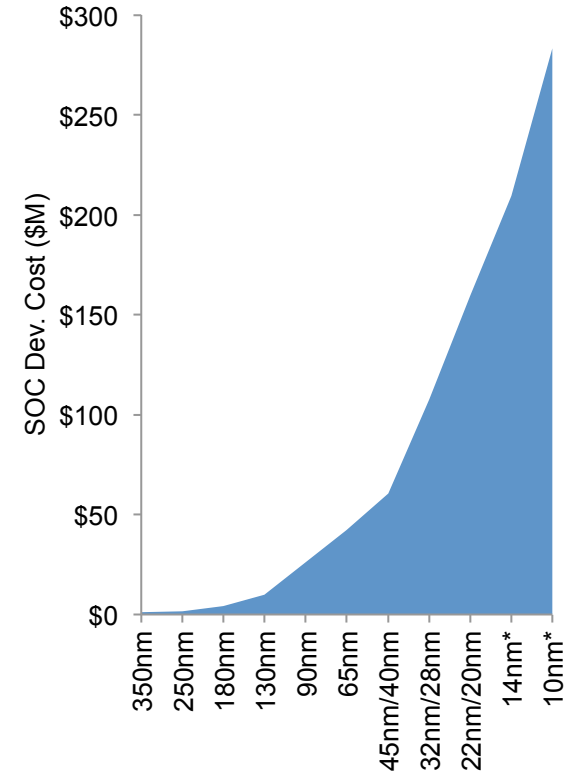
Source: Semico 2013

Chip-only ventures headed for extinction?

silicon *CATALYST*

- Long time to revenue

- Relatively large investment required

- Few IPO successes

- Less investment from traditional sources

We are in the "post-chip" era

# of Seed/Series A Deals

54   53
32   28   42   37
22   22
4   4   7   6

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011

Source: GSA

Semiconductors once was a haven for entrepreneurism and startups ... now consolidation is our reality
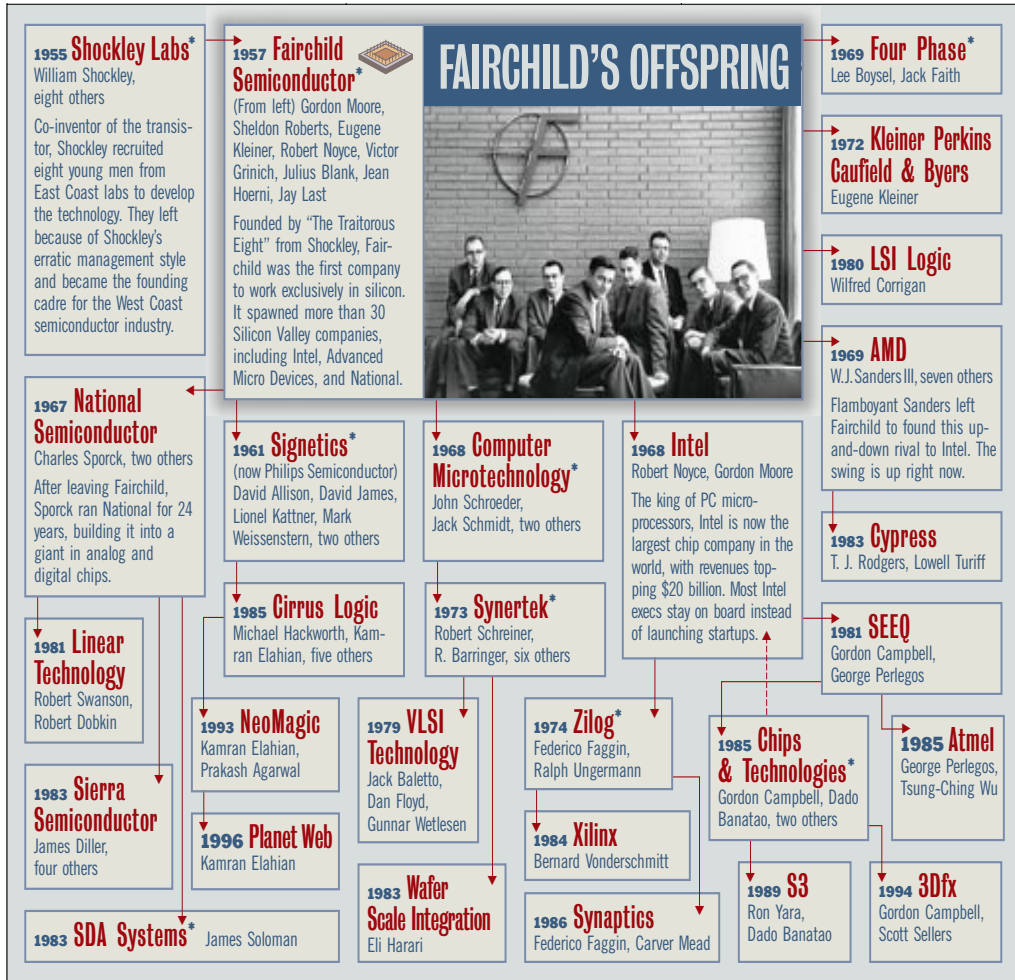
1960's

2010's

Evolution of the supply chain structure

Historical

Integrated Device Manufacturer (IDM)

Systems

Design

Packaging and Assembly

Chip Technology

EDA Tools

Equipment and Materials

Now

System

Memory
Logic
IDM

Fabless
Fablite

Foundries

Package
and
Assembly

EDA
Equipment
Materials
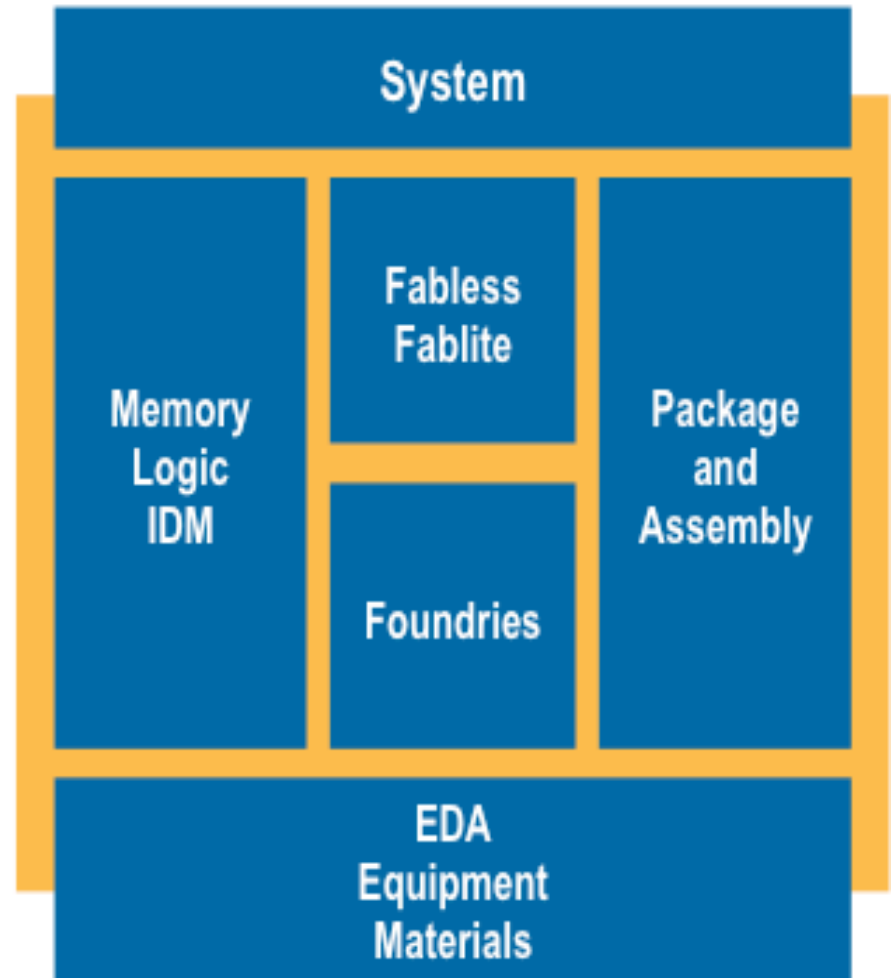
Innovation through acquisition can be a greater source of growth for established companies

Semiconductor M&A & market-share growth is 50% of other Industries

Other Industry Ave	55%
Semis	27%
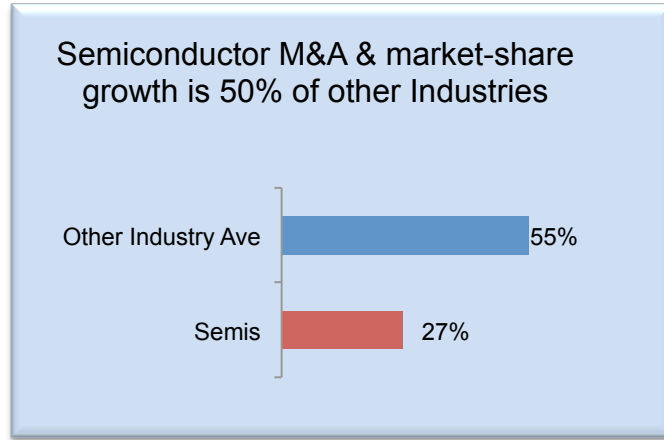
"*If you attempt disruptive innovation within your organizational boundaries, the immune system will come and attack you*"
Salim Ishmail, Singularity Univ. and Brickhouse, Yahoo's internal incubator

100 — Google
18 — amazon
41 — facebook
23 — Apple

# of Companies Bought Since 2009

The Fastest Growing Companies Innovate Thru Acquisition

The biotech industry still has a healthy start-up environment because of "solutions and acquisition" focus
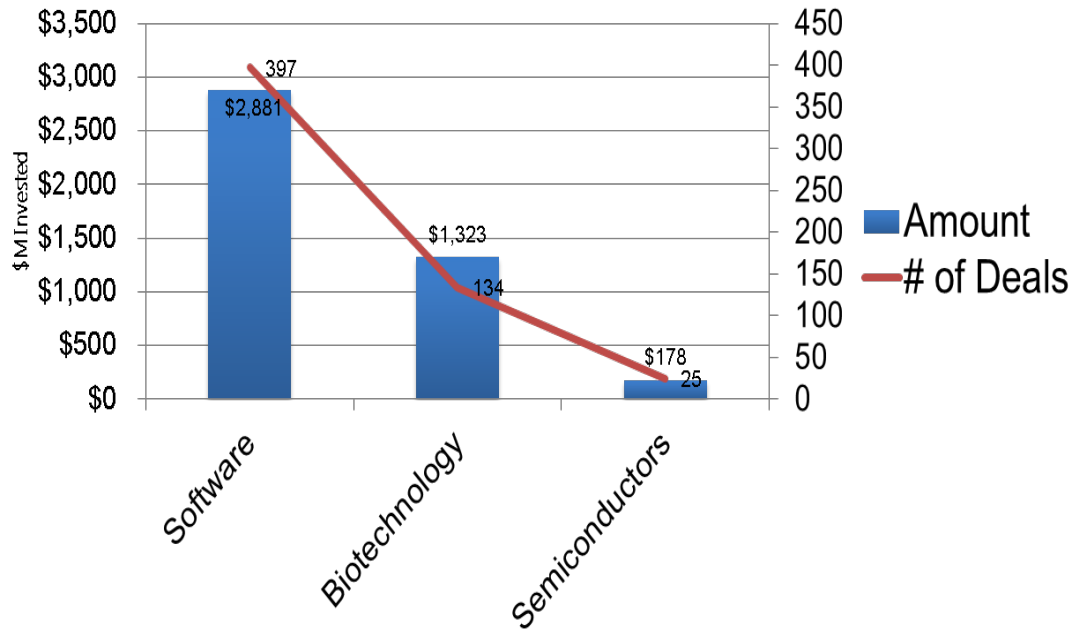
Biotech is second only to software in number and amount of deals
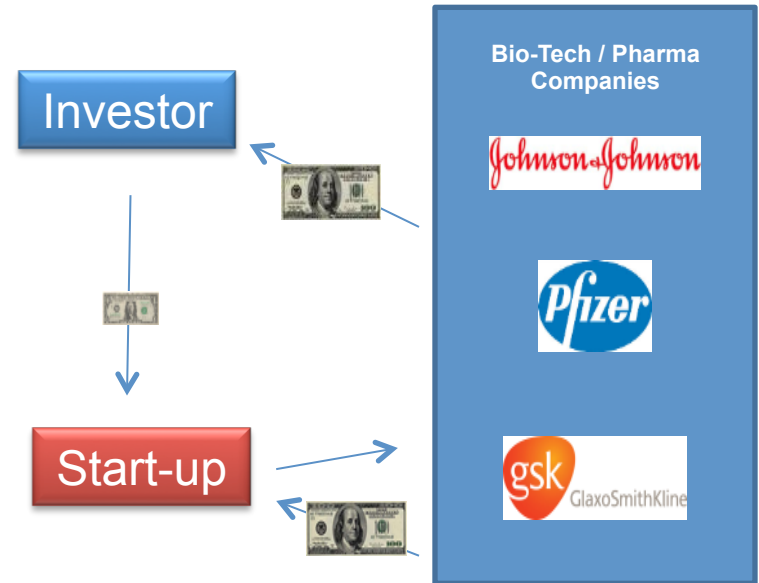
Source: PWC, US Investments by Industry / Q4 2013

"Point solution" start-ups selling to established companies

Semiconductors have not leveraged an incubator model ... and instead use angels, VC's and company venture funds

# of Incubators

2000

Software / Apps | Silicon focused
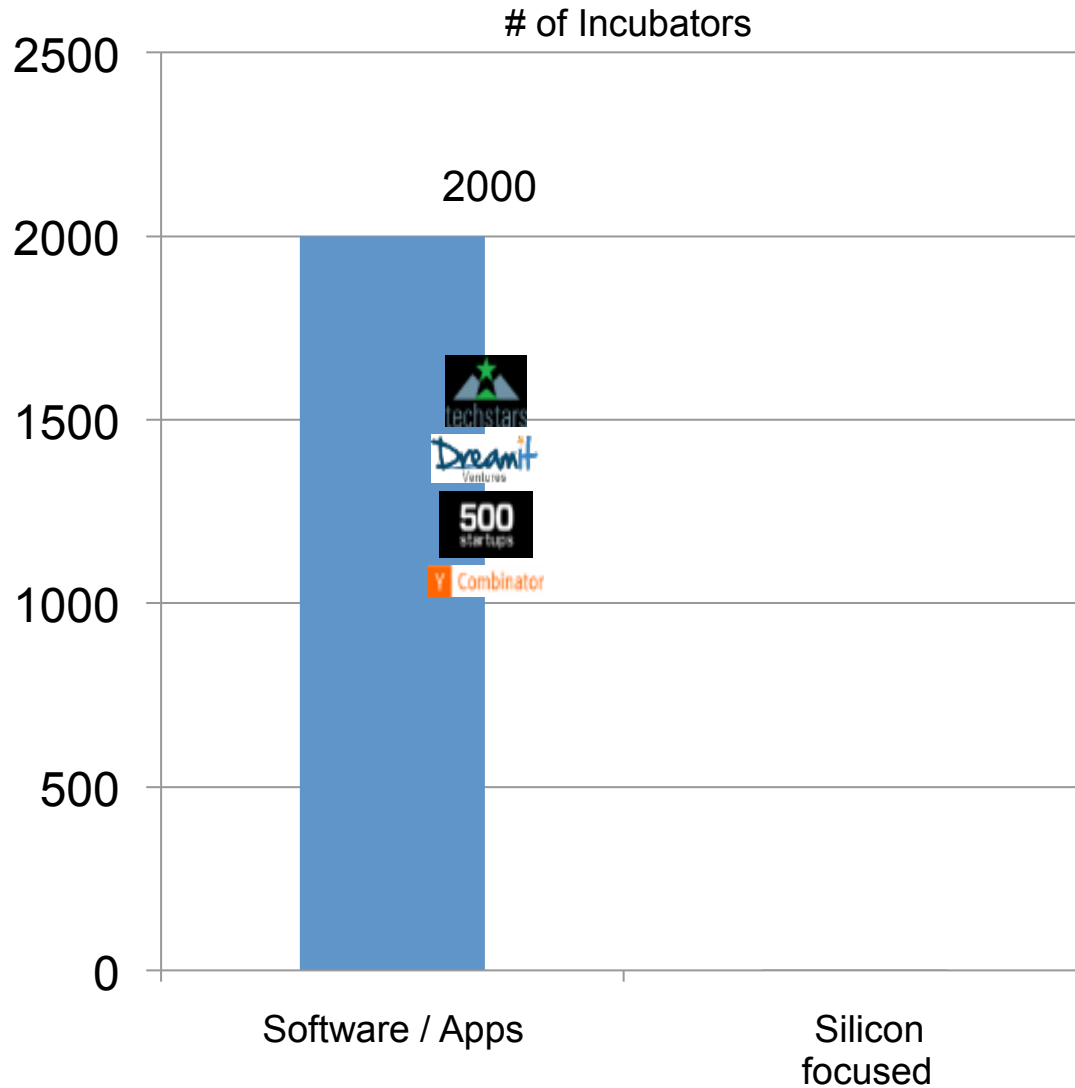
Yet there is tremendous opportunity … these all need solutions in silicon

Mobile computing will continue to converge functions and drive compute power

Internet of things will drive mobile processing at low power with ubiquitous RF

Coverage and insatiable bandwidth needs will drive **Next-Gen Wireless**

Increasing **Security** concerns at all levels: government, enterprise and personal

The Cloud will cause upheaval in IT

Personalization through technology and logistics

Energy Efficiency is needed for sustainability & lower cost of ownership

Mega-Trends

"$19 Trillion Market By 2020" John Chambers, Cisco

Global Internet Device Installed Base Forecast

Wearables
Smart TVs
Internet Of Things
Tablets
Smartphones
PCs

Source: Gartner, IDC, Strategy Analytics, Machina Research, company filings, BII estimates

Medical   **Transportation**   **Wearables & Sensors**

Next-Gen Wireless

Energy

This is the best time ever to innovate in silicon as we enter the IoT "Era of Devices"

THE WALL STREET JOURNAL.

Why Silicon Valley Will Continue to Rule the Tech Economy

Human talent and research and design labs are arriving to dominate the new era of devices.

By MICHAEL S. MALONE
Updated Aug. 22, 2014 6:51 p.m. ET

Silicon Valley, especially its San Francisco wing, is richer and more powerful than ever. Yet there are growing murmurs—underscored by plateauing new-jobs numbers and housing prices, street protests in San Francisco over the new 'plutocrats,' the lack of exciting new products and a decline of early-stage new investments—that Silicon Valley has finally peaked and begun the downhill slide to irrelevance.

Slide? Perhaps. The Valley has always been characterized by a four-year boom-bust cycle, and the electronics industry is overdue for such a downturn. Yet there is very good reason to believe that not only will the Valley return bigger and stronger than ever, but that it will further consolidate its position against all comers as the World's High Tech Capital. Here's why:

• *Success breeds success.* A major new report being prepared by the Silicon Valley Competitiveness and Innovation Project has found that the region's dominance is still decisive and growing. While a decade ago the nation's various tech centers showed a relative balance in creating high-value companies, Silicon Valley (including San Francisco) has now jumped far ahead. The average worker in Silicon Valley generated 50% more output per year than the average U.S. worker in 2012, according to Collaborative Economics Inc.

• *The Long Wave*: Most observers appreciate the Valley's four-year cycle, but few have ever noticed a much longer, 20-year cycle in electronics. For nearly two decades since the beginning of the dot-com boom, the Valley has been dominated by software. We have lived in the Era of Code—and with it the gestalt of the programmer. This person is young, single, urban, visionary and utopian: the frat boy turned tycoon. But that era is ending, as a cycle of hardware begins to assert itself in the form of watches, wearables, mobile health, autonomous cars, drones, 3-D printing and a revolution in sensors—all tied together by the cloudlike Internet of Things.

We are entering the Era of Devices. This will be led by builders: older, with a family, suburban and pragmatic. This will undoubtedly result in a Valley more like that of the calculator and PC eras in its style, people and attitudes, and a break from the increasingly protested-against titans of social networking.

Michael Malone:

… lack of exciting new products and a decline of early-stage new investments.

Most observers appreciate the Valley's four-year cycle, but few have ever noticed a much longer, 20-year cycle in electronics.

We have lived in the Era of Code …. But that era is ending, as the cycle of hardware begins to asset itself in the form of watches, wearables, mobile health, autonomous cars, drones, 3D printing and a revolution in sensors, all tied together by a cloud-like Internet of Things.

We are entering the Era of Devices. This will be led by builders

Context is everything

The future is here. It is just not evenly distributed.

William Gibson

Gordon Gekko, Wall Street, 1987

Source: 20th Century Fox

Context is everything … "Wall Street", digital re-release in 2014

Gordon Gekko, Wall Street, 1987

Source: 20th Century Fox
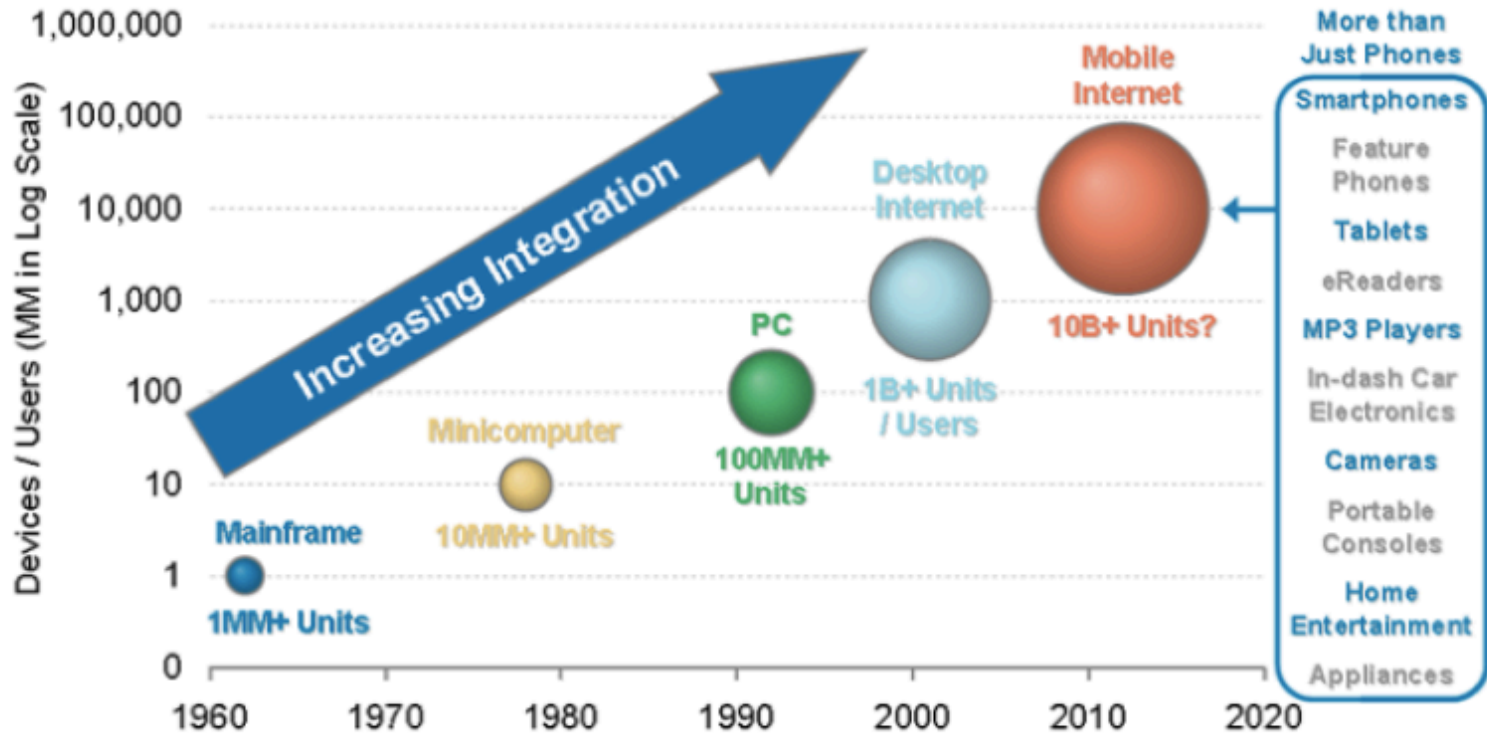
- IoT Critical Analysis -

IoT – Use the Log scale

Each new computing cycle typically generates around 10x the installed base of the previous cycle

Devices or users in millions; logarithmic scale

Devices / Users (MM in Log Scale)

1,000,000

100,000 — Mobile Internet

10,000 — Desktop Internet

1,000

100 — PC · 1B+ Units / Users

10 — Minicomputer

1 — Mainframe

0

Increasing Integration

10B+ Units?

100MM+ Units

10MM+ Units

1MM+ Units

More than Just Phones

Smartphones
Feature Phones
Tablets
eReaders
MP3 Players
In-dash Car Electronics
Cameras
Portable Consoles
Home Entertainment
Appliances

1960   1970   1980   1990   2000   2010   2020

Source: Morgan Stanley Mobile Internet Report (12/09)

Where will growth come from?

By 2020, between $9T (IDC) and $19T IoT market (Cisco, John Chambers)

Global Internet Device Installed Base Forecast

Wearables
Smart TVs
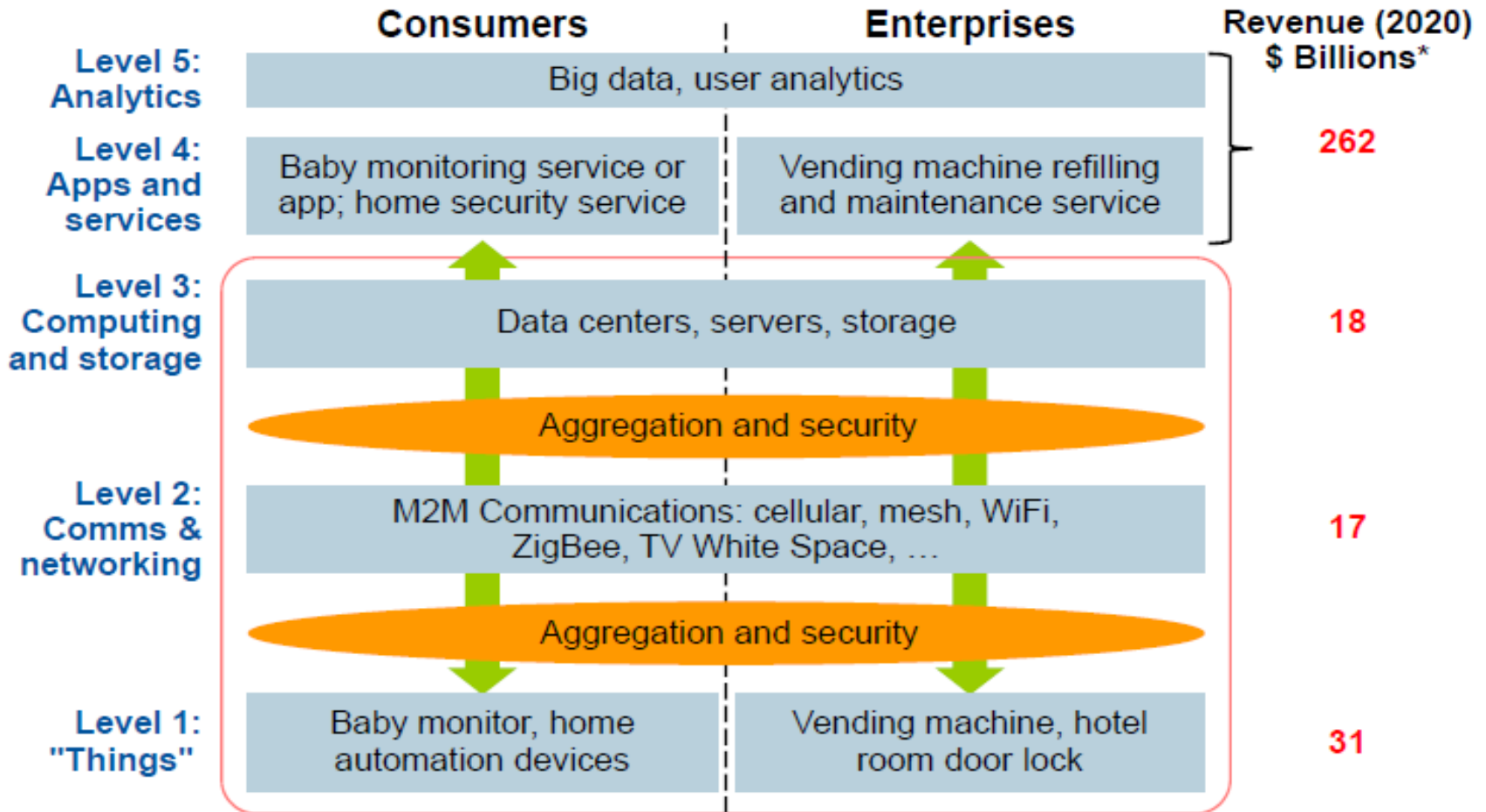Internet Of Things
Tablets
Smartphones
PCs
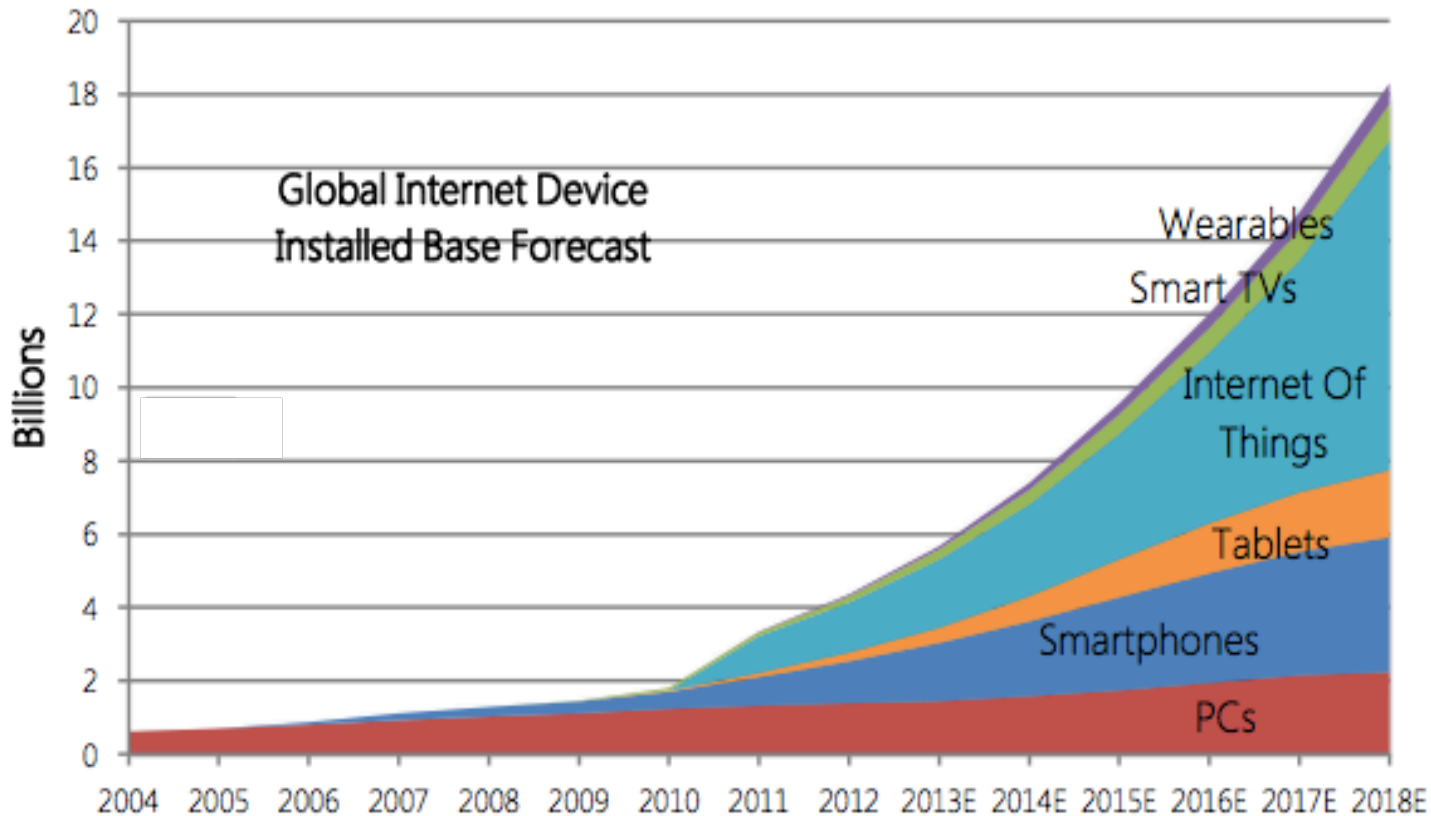
Source: Gartner, IDC, Strategy Analytics, Machina Research, company filings, BII estimates

IoT – Industry sector perspective

Internet of Things: 2020 Economic Value-Add by Industry Sector

Total: $1.9 Trillion

- Communications 3%
- Agriculture 4%
- Real Estate & Business Services 4%
- Other 4%
- Manufacturing 15%
- Healthcare Providers 15%
- Utilities 5%
- Transportation 6%
- Government 7%
- Computing Services 8%
- Retail & Wholesale 8%
- Banking & Securities 10%
- Insurance 11%

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17

Source: Gartner
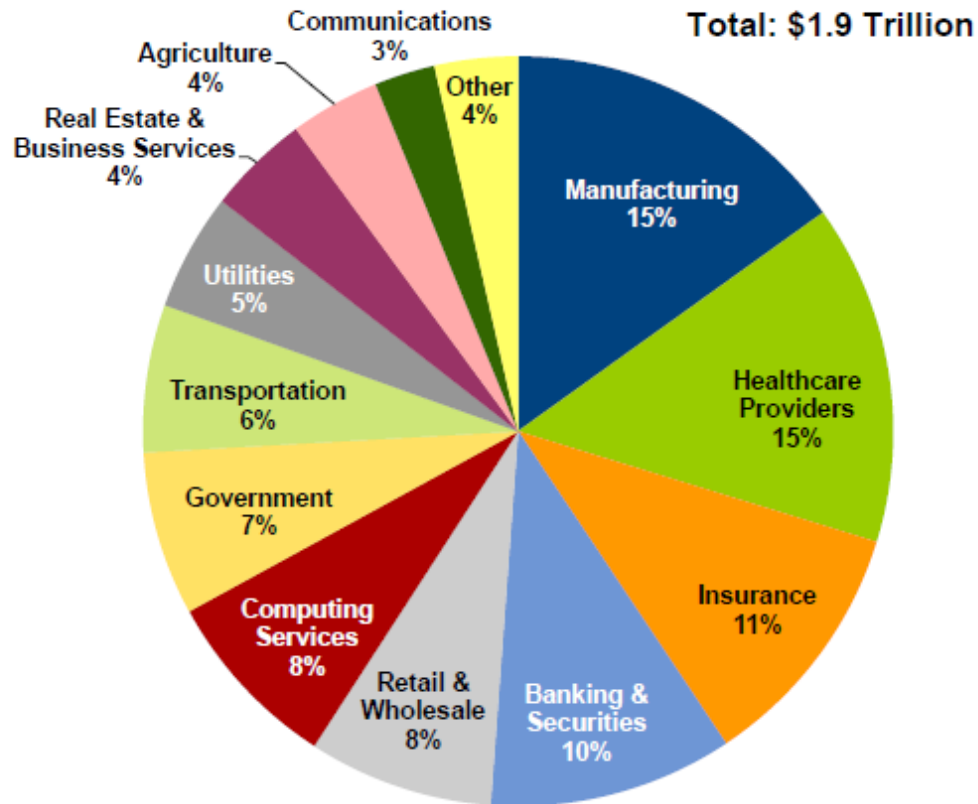
IoT – Market opportunities

	Consumers	Enterprises	Revenue (2020) $ Billions*
Level 5: Analytics	Big data, user analytics		
Level 4: Apps and services	Baby monitoring service or app; home security service	Vending machine refilling and maintenance service	262
Level 3: Computing and storage	Data centers, servers, storage		18
	Aggregation and security		
Level 2: Comms & networking	M2M Communications: cellular, mesh, WiFi, ZigBee, TV White Space, …		17
	Aggregation and security		
Level 1: "Things"	Baby monitor, home automation devices	Vending machine, hotel room door lock	31

Source: Gartner
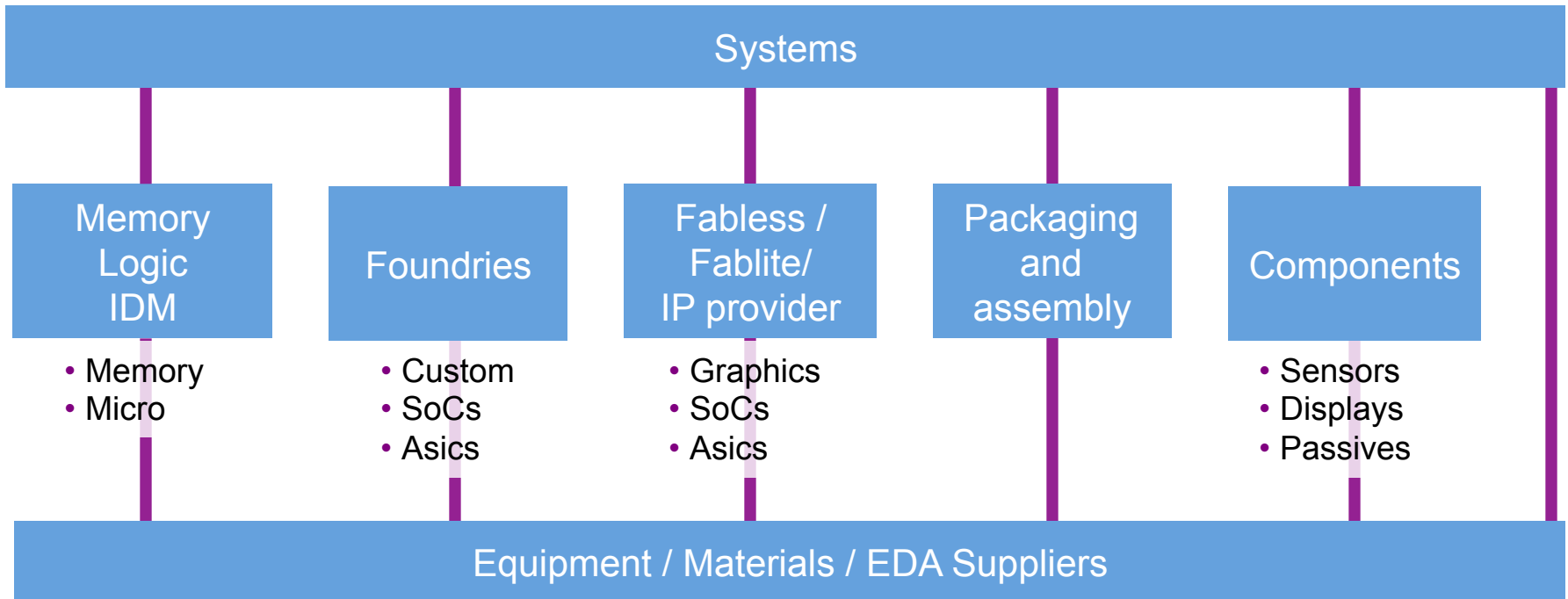
IoT – Some companies to watch

- Qualcomm   wireless IC's and infrastructure
- Samsung   IC's, devices, and internal mfg
- Intel   IC's and internal mfg.
- ARM   low power processors
- Google   Glass, Android, Next (thermostats), cloud
- Apple   devices, platforms
- Microsoft   OS, devices, software infrastructure, cloud
- Oracle   Java, databases, software infrastructure, cloud
- Cisco   networking
- GE   industrial applications
- Amazon   cloud service (AWS), devices
- Nike   fitness wearables infrastructure
- IBM   smart infrastructure and analytics , WATSON, cloud

IoT – How does industry structure evolve from today's reality?

Systems

Memory Logic IDM	Foundries	Fabless / Fablite/ IP provider	Packaging and assembly	Components
• Memory • Micro	• Custom • SoCs • Asics	• Graphics • SoCs • Asics		• Sensors • Displays • Passives

Equipment / Materials / EDA Suppliers

IoT – What's missing

- Significant gaps in standards

- Capable hardware and software platforms

- Truly power-efficient components

- Low cost/high performance components packaging

- Battery technology or energy harvesting

- Ability to sense many things of interest

- Context awareness

- Security

IoT – Cost perspective

For 10-100x THINGS per person, then they must cost 5-30X less

$207   Apple 5S phone w/ 32Gb
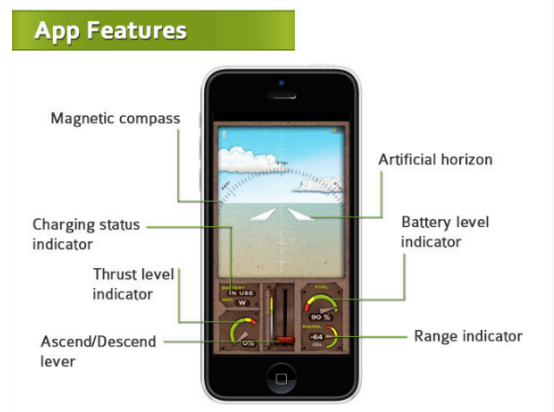
$35   ZTE U793 low end Android phone

$17   Fitbit wearable
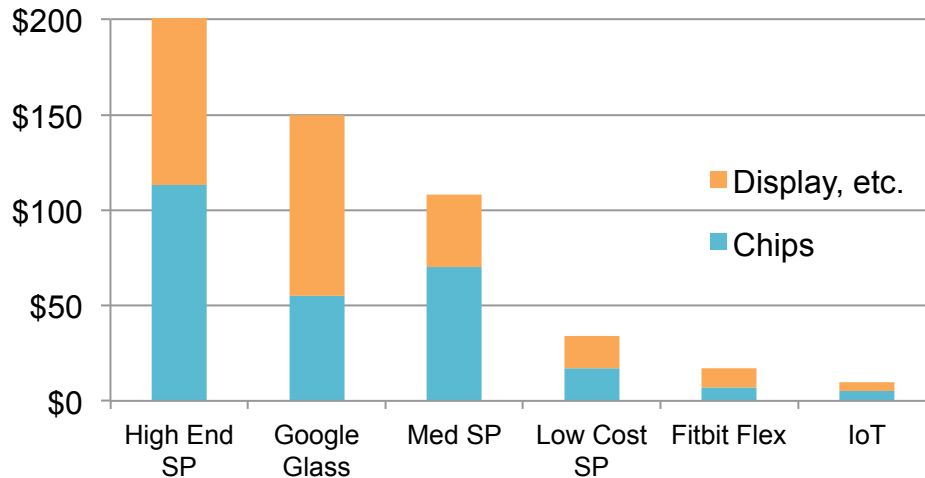
Smartphone Bill of Materials

BOM (front of the phone)	Avg. Cost ($)
NAND Flash (16GB)	$20–22
Display	$18–20
Applications Processor	$15–17
Baseband	$10–13
Touch Screen	$11–13
DRAM	$8–10
FEM and Misc RF	$4–5
Combo-chip (WiFi, BT)	$3–4
Power Management	$3–4
Power Amplifier	$3–4
Touch Controller	$2–3
GPS	$1–2
Image Sensors ASP	$1–2

Chart: Display, etc. / Chips — High End SP, Google Glass, Med SP, Low Cost SP, Fitbit Flex, IoT

IoT – The small build-it-yourself DRONE

The PowerUp 3.0 Smart Module

App Features

- Magnetic compass
- Artificial horizon
- Charging status indicator
- Battery level indicator
- Thrust level indicator
- Ascend/Descend lever
- Range indicator

IoT – Ingestible "camera pill" for colon cancer detection

PillCam® COLON

Safe. Non-Invasive. Accurate.

PillCam COLON uses a miniaturized camera contained in a disposable capsule that naturally passes through the digestive system, allowing physicians to directly view the entire colon, without sedation or radiation. For patients who have had an incomplete colonoscopy which was not due to poor prep, PillCam COLON can be used to non-invasively complete the colon exam.

Undergoing a complete colon evaluation is extremely important for the detection of polyps, small clumps of cells that form in the lining of the colon that can become cancerous over time. PillCam COLON is the only accurate, non-invasive test that directly visualizes the colon to detect polyps, which is the first step in preventing colorectal cancer.

Source: Given Imaging

IoT – Personal articles tracking
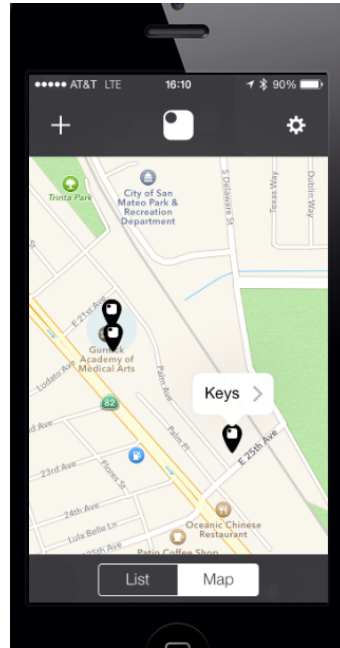
IoT – Temporary "sensor bandages"
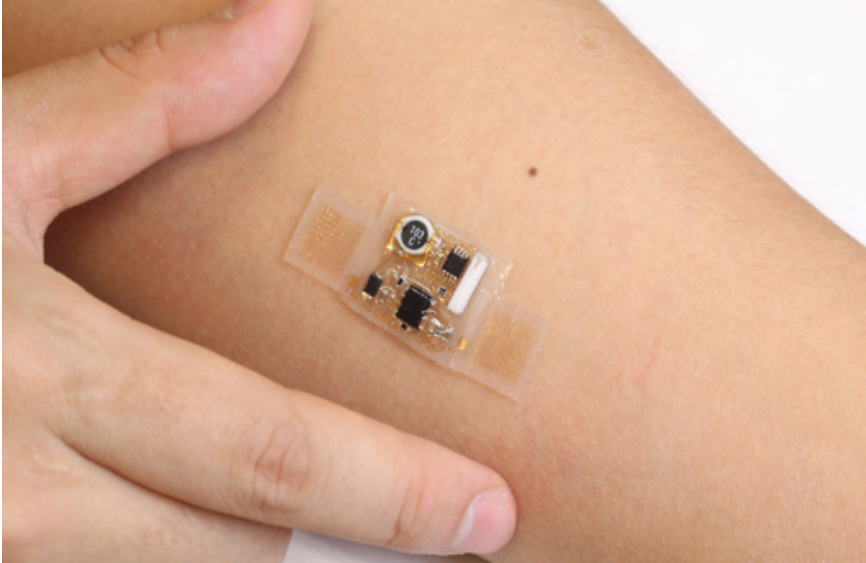
Includes:
- wireless antennas
- temperature sensor
- heart rate sensors
- battery

Source: M10 wearable computers, Cambridge MA
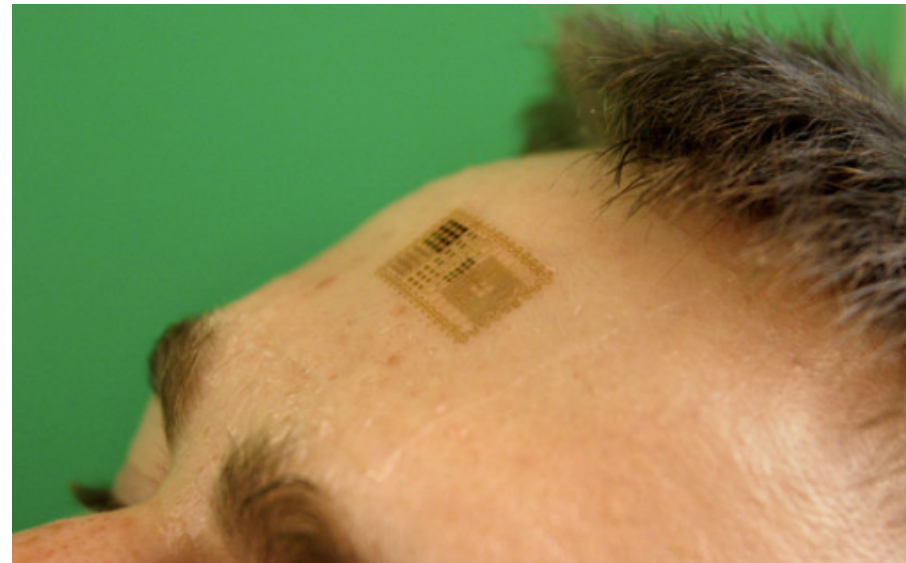
IoT – Wireless controller/radio-on-a-chip, powered by EM waves from incoming signal received by its antenna
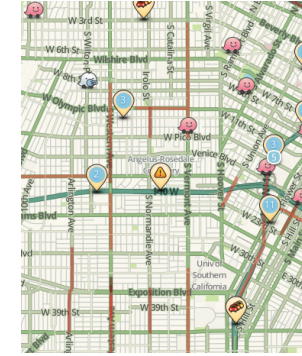
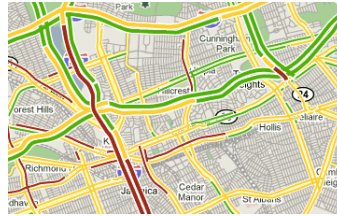Source: Stanford, UC Berkeley, ST prototype
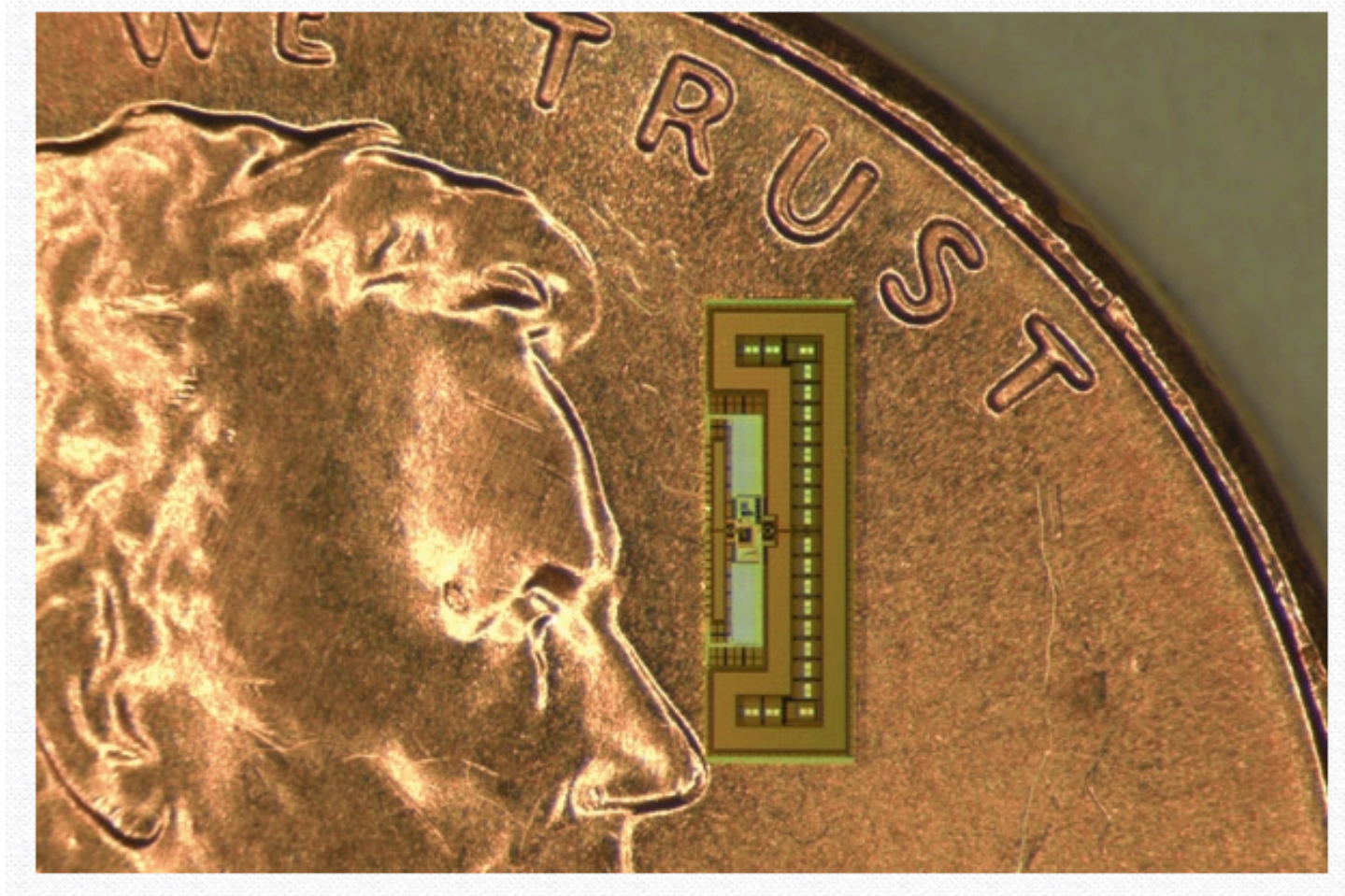
IoT – Innovation using deployed Smartphone sensors

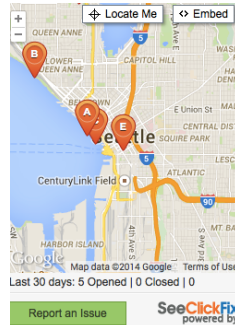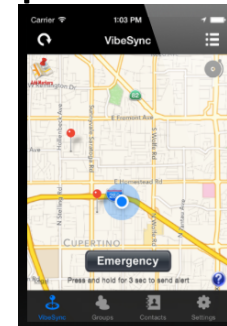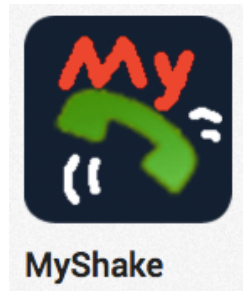Traffic detection   Google Maps   Waze

Road Repair   ClickFix   Boston
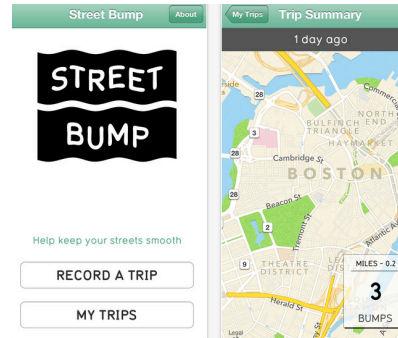
Earthquake warning   California - Napa Valley

IoT – A critical perspective

- Huge potential for unit growth, far exceeding expectations for smartphones and computing devices

- Estimates range from 25-100B devices by 2020 and acknowledgement that they could be off by 5-10x

- No clear killer app or early leader has emerged yet

- Applications to be widely distributed across industry segments and not exclusively in consumer electronics

- Far less focus and critical thinking on how much it needs to cost to be affordable
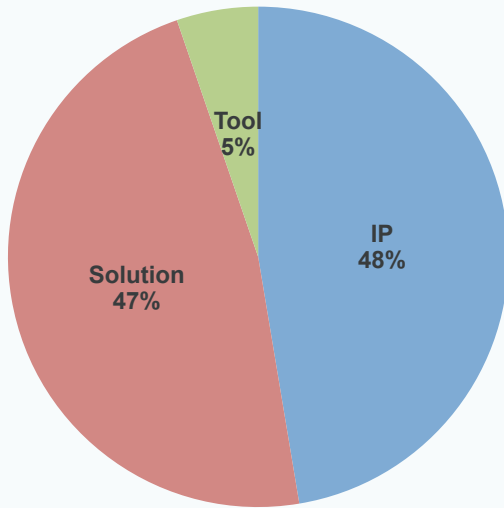
- Addressing the barriers for semiconductor startups -

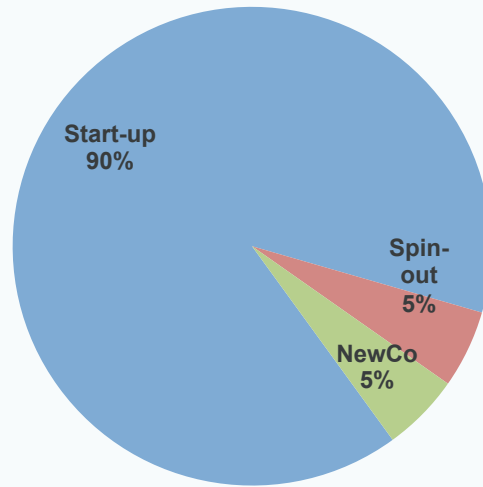# What alternatives are available to semiconductor startups?

	Friends and Family	Bootstrap	Angel	Incubator	Gov. Programs & grants	Crowd funding	Strategic Corp. Partner	Venture Capital
Pros	Small $'s	Certainty of income	Just 1 person to convince	Network and services	Often non-dilutive	Promotes MVP approach	Market feedback (at least 1)	Network and credibility
Cons	Only $'s	May go off course w/ small projects	Only $'s	Low $'s	On timetable and terms of agency	Short term horizon	Partner control / influence	Dilution
			Hard to find	Short time to incubate				Hard to obtain

45 semiconductor startup companies profiled

Product

- Tool 5%
- IP 48%
- Solution 47%

Status

- Start-up 90%
- Spin-out 5%
- NewCo 5%

IoT Segments

Segment	Number of Companies
Biotech	2
Extend Moore's Law	17
Transportation	4
Energy	8
General IoT	16
Mobile	26

What do semiconductor startups say they struggle with?

Rank Issues

- Finding engineering...
- Find sales and marketing...
- Getting EDA and lab tools
- Getting prototypes made
- Receiving adequate...
- G&A (healthcare,...

Rank Expenses

- EDA Tools
- IP
- Test Equipment
- Silicon Prototyping
- Facilities
- Salaries
- Legal

Top 3 Challenges

- Raising seed money
- Managing the burn rate /...
- The time it took to get ...
- Technical challenges
- Hiring the right team
- The cost of development...
- The cost of prototyping...
- Systems Integration...
- IP & Legal Issues

Source: Silicon Catalyst, 15 startups surveyed in 2014

What do semiconductor startups say they struggle with?

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Top 3 Challenges

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- The cost of prototyping...
- Systems Integration...
- IP & Legal Issues

EDA, Prototypes, Test, $'s

Source: Silicon Catalyst, 15 startups surveyed in 2014
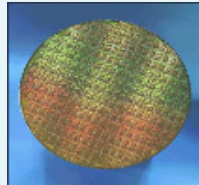
What do solutions in silicon startups need?

Semiconductor startups priorities
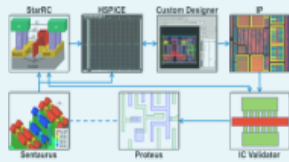
EDA Tools

MPW Prototyping

Lab and test Equipment
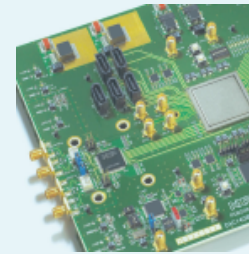
DFM, System Integration & Prototyping

$

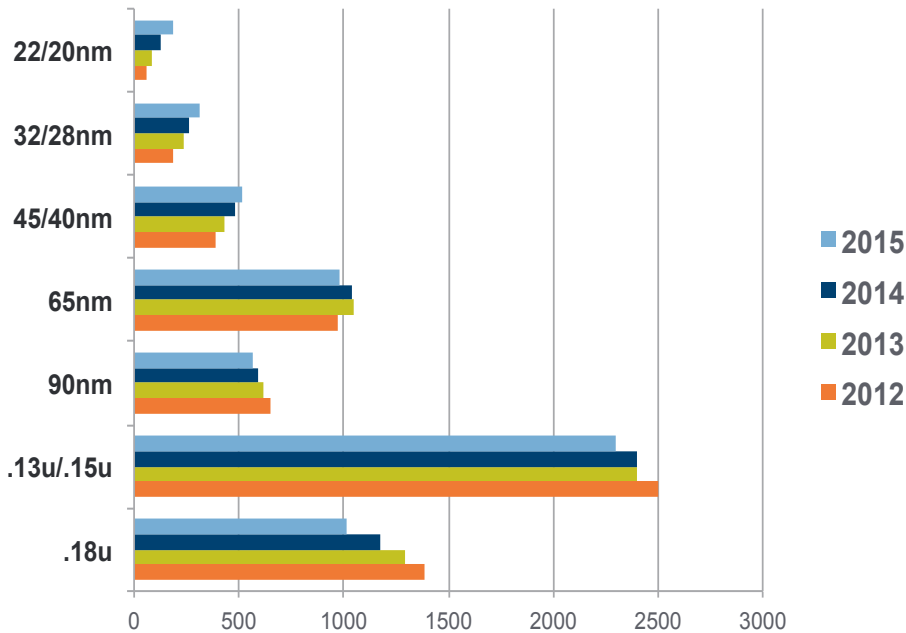**Mentoring**

Secure Work Space

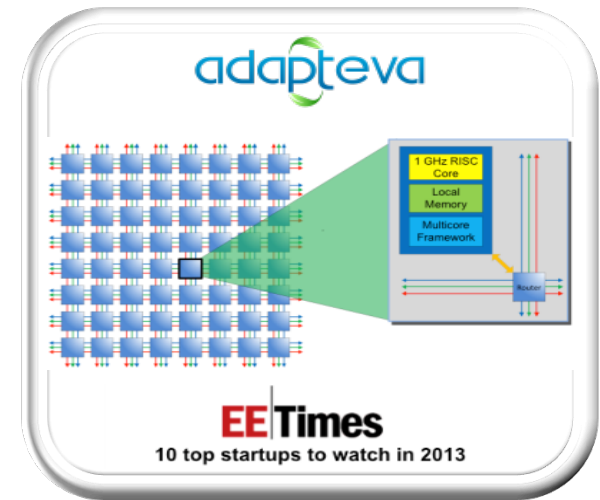**Business & Legal Support**

Lots of Pizza

While you can spend $100M starting a semiconductor company, it is not necessary or typical

130nm has the most design starts
65nm & 45nm have yet to peak

Legend:
- 2015
- 2014
- 2013
- 2012
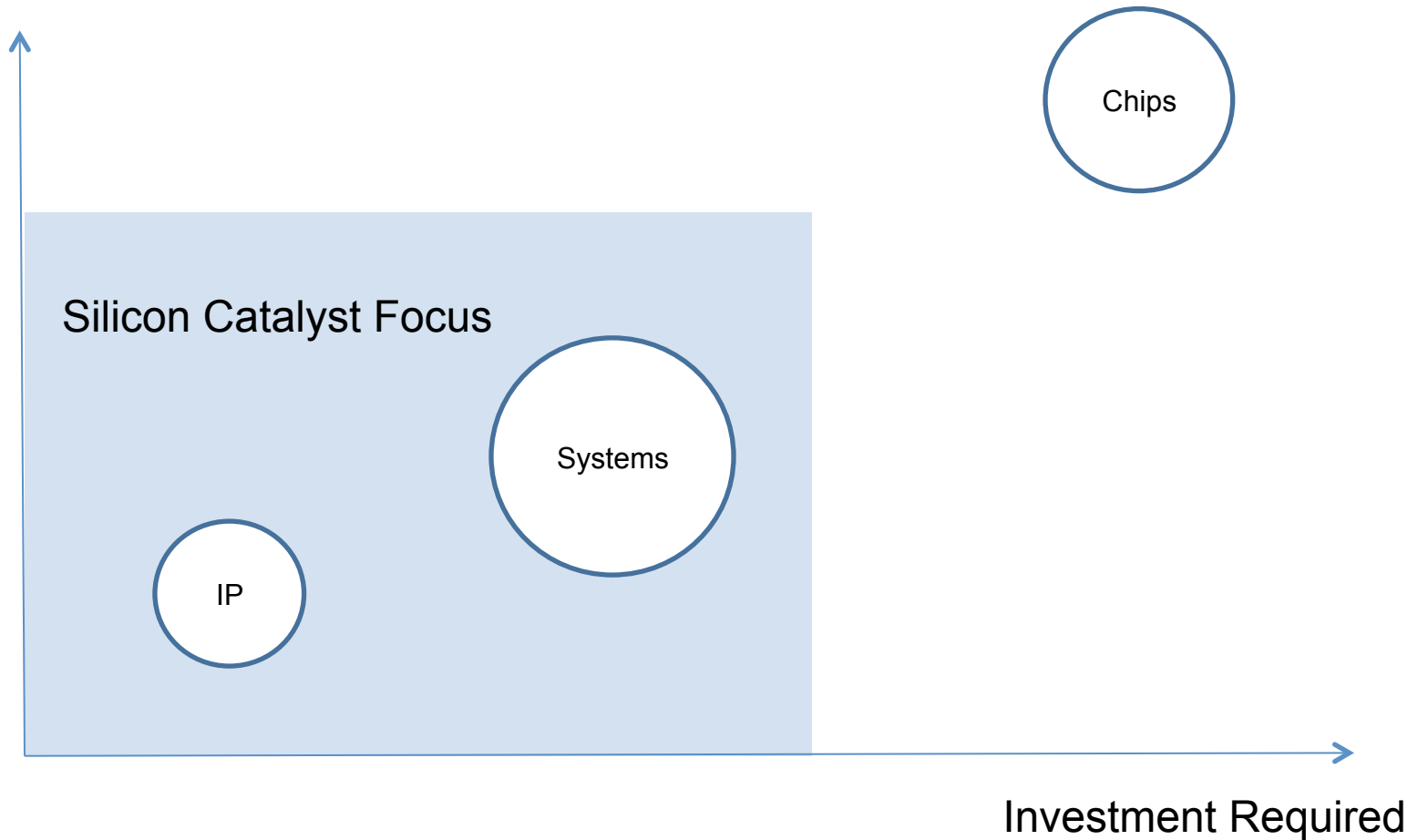
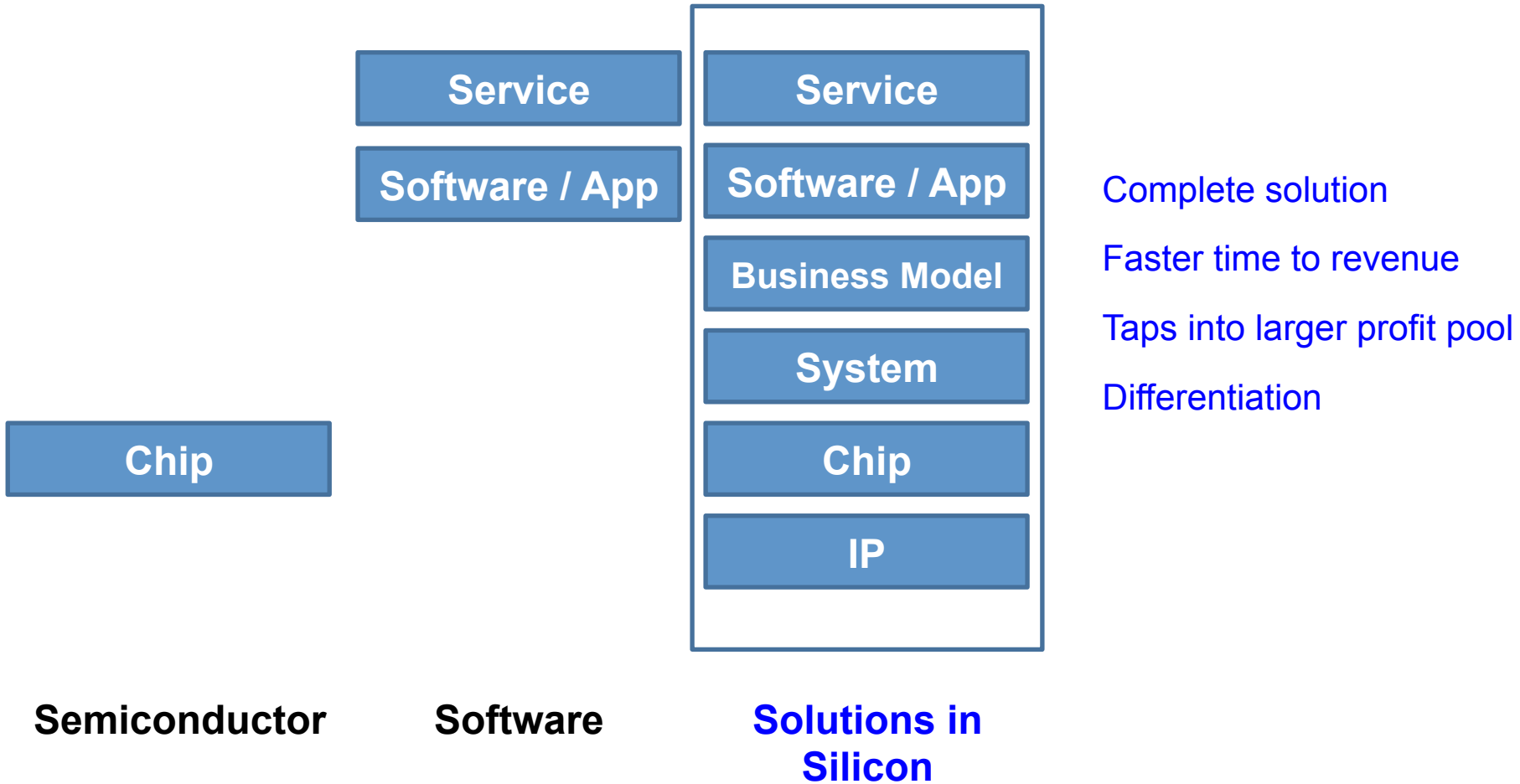*Source: I.B.S. 2011*

Even 28nm Can Be Done Frugally

- 1st 50GFLOPS/Watt processor
- 1st crowd sourced funded semiconductor company
- Total invested <$5M

IP and systems companies have faster time to revenue and lower investment required than chips


Time To Revenue (vertical axis)

Investment Required (horizontal axis)

Silicon Catalyst Focus

IP

Systems

Chips

The importance of "Solutions in Silicon" approach?

Service

Software / App

Service

Software / App

Business Model

System

Chip

Chip

IP

Complete solution

Faster time to revenue

Taps into larger profit pool

Differentiation

Semiconductor **Software** **Solutions in Silicon**
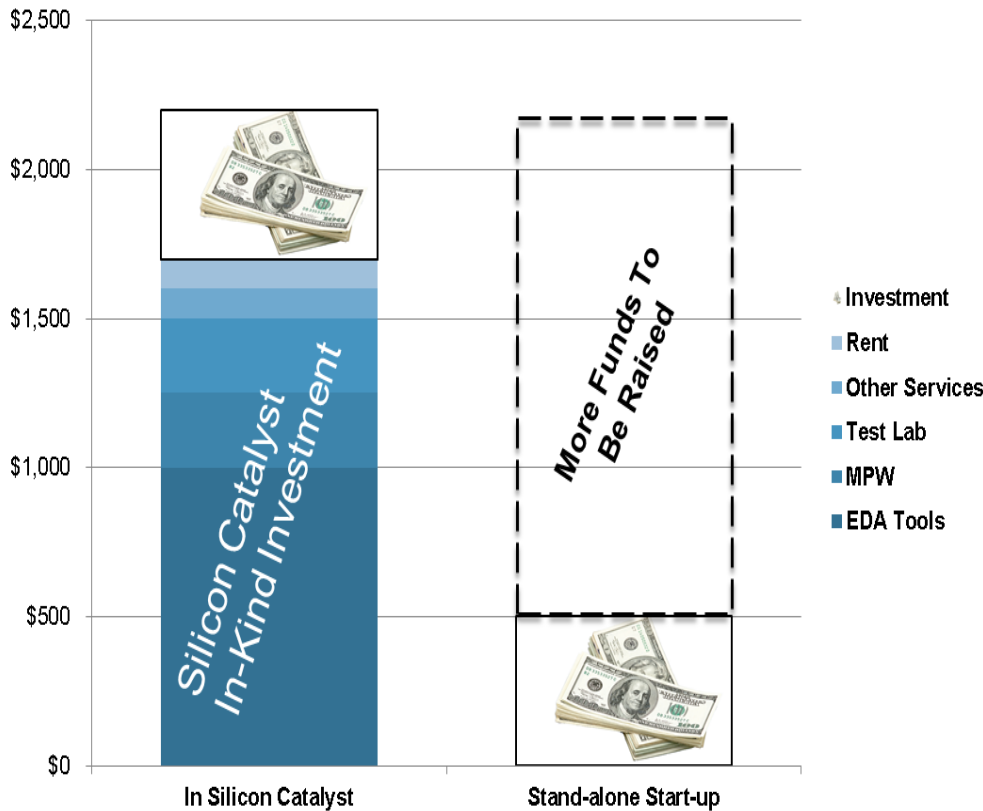
The Silicon Catalyst transfer function: we accelerate start-ups with ideas into companies ready for exit
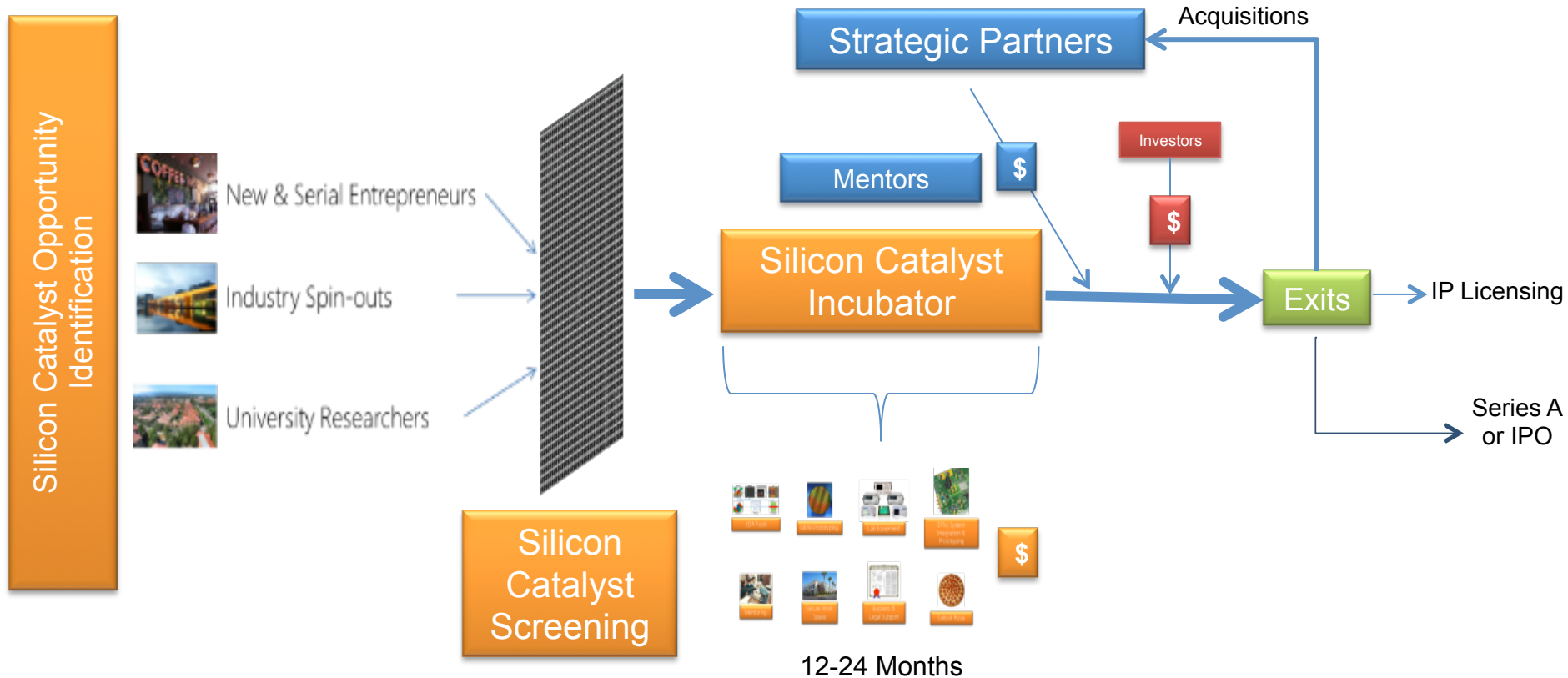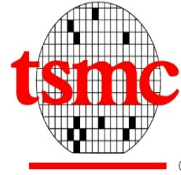
Silicon Catalyst minimizes need to raise seed capital and makes any cash investment more impactful

- Founders can get to work building a team and executing

- Founders retain more equity

- Cash goes to innovation, not table stakes

- Start-up is more "fund-worthy"

We are partnering with industry leaders

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Introducing Silicon Catalyst, the First Incubator for Semiconductor Solution Start-Ups

SILICON VALLEY, CA--(Marketwired - Dec 9, 2014) - Silicon Catalyst today launched the industry's first incubator for semiconductor solution start-ups. While there are many incubators and accelerators for software and even some for hardware, this is the world's first focused exclusively on semiconductor solutions. Silicon Catalyst will address the challenges faced by start-ups when going from idea to company formation to prototype, along with the industry-wide concern about the lack of fund-worthy start-ups to drive novel innovation and growth.

The Silicon Catalyst model is unique:
- Build a coalition of companies to help start-ups reduce the complexity of semiconductor innovation
- Incubate a select number of start-ups each year and provide them the tools and support needed to get to work, rather than spend precious time hunting for funding
- Assemble a world-class network of mentors to guide these entrepreneurs

Key to the Silicon Catalyst business model is providing access to mentors who believe it is in the interest of the entire industry to support start-ups. The first of these mentoring companies include EDA and IP provider Synopsys; test & measurement equipment company Keysight; and pure-play semiconductor foundry TSMC.

In addition to these companies, Silicon Catalyst is in discussions to add to its rapidly expanding network with companies from the semiconductor ecosystem ranging from enablement to fabless to systems companies that will help mentor qualified start-ups admitted to the incubator …..

More In The Works

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